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THE IMPACT OF ACUTE EXPOSURE TO MLX I³DOME IN RECOVERY AFTER INTENSE EXERCISE:

Effects on blood and muscle parameters, sport performance and wellbeing.

Pr. Hausswirth C.[1,2,3], Dr. Nesi X.[1],
Dr. Gueneron J. MD[1] - cardiologist[1], Dr. Duforez F. MD[4]

1. beScored Institute, Sophia-Antipolis (France); 2. Université de Côte d'Azur, Nice (France) ;
3. University of Technology, Sydney (Australia) ; 4. European Sleep Center, ESC, Paris (France)

Sommaire

Context

The world of SPA is gradually drawing away from the mere use of saunas and steam rooms as well as the usual implementation of traditional massages. After this long period of health crisis and the lack of access to wellbeing-generating therapies, the time has come to use Science to prove the benefits related to the various care pathways available. Hands-free devices which no longer depend on an operator are arriving on the market of wellness in order to efficiently increase one's health capital – both physical and psychological. In this context, we have conducted the present study on athletic people and studied their recovery. The works conducted and their results could have a major impact on the world of wellbeing, SPA and sport.

Introduction

Regarding the sport context, endurance events such as running, cycling or skiing require extensive physical and psychological involvement of the athlete both in training and in competition in order to succeed (Hausswirth and Mujika 2013). Well-trained runners complete training sessions practically every day or every other day, and so acute recovery becomes a vital factor in supporting supplementary training loads or competitions (Halson and Jeukendrup 2004; Barnett 2006). Especially when an eccentric work is performed, muscular recovery then becomes pertinent. It is well documented that eccentric contractions, which involve force generation in a lengthening muscle, procure severe structural damage in muscles, affecting their contractile properties (Nicol et al. 2006). Within days after exercise, these structural alterations are classically accompanied by physiological and subjective perceptions of muscle damage that delay recovery. The increase of blood acidosis and sensations of pain or discomfort (i.e. delayed-onset-muscle-soreness, DOMS) typically occur after eccentric loading of the skeletal muscle and are classically used to study the extent of muscle damage (Cheung et al. 2003; Jakeman et al. 2010; Sellwood et al. 2007). In addition, the ensuing decline in maximal force generating capacity constitutes a relevant indicator of exercise-induced muscle damage (EIMD) (Gauché et al. 2007).

A variety of authorized strategies are proposed to alleviate the deleterious effects of EIMD and enhance recovery such as nutritional supplementation (Gauché et al. 2007), post-exercise massages (Weerapong et al. 2005), compressive garments (Jakeman et al. 2010), water immersion (Pfeiffer et al. 2009), whole-body cryotherapy (Pournot and Hausswirth 2011) or body exposure to warmth (Hausswirth et al. 2011). Other recovery modalities such as far-infrared (FIR) therapy are also used to relieve pain in patients with muscular disorders and more recently have been considered as an efficient recovery strategy in sport (Hausswirth et al. 2011; Masuda et al. 2005a; Masuda et al. 2005b). FIR therapy generally consists in a 30 min body exposure to FIR in a specially built apparatus. FIRs are invisible to the human eye but they are felt in the warmth their produce, in the order of 45°C. The potential positive effects of FIR therapy during recovery are mainly based on the increase of the peripheral flow due to vasodilatation under the influence of heat, which could improve drainage of the edema, limit the inflammation and perceived pain and thus improve muscle repair (Lin et al. 2007). Furthermore, by penetrating the skin, the FIR energy could break down the clusters of water molecules, which could reduce the edema and facilitate the release of metabolic wastes (Lin et al. 2007), all the while providing a feeling of already proven wellbeing (Hausswirth et al. 2011). The effect of FIR therapy on recovery is mainly based on the observations and the usual recourse. To this day, the only verified effect of FIR is a reduction of perceived pain and muscle fatigue, induced by a raise of endorphin production (Melzack and Well, 2015). The benefits on athletes' recovery after an eccentric constraining exercise and on wellbeing have not been studied to this day. In addition, negative air ionization for athletes could have complementary effects with long-wave infrared energy.

A great interest has been granted to the potential effects of negative air ionization (NAI) on human health and wellbeing. According to Krueger and Reed (1976), though air ions were already known in the late 19th century, the plural physiological responses result in a lack of precise comprehension of all the possible effects including a clear idea of the actual recorded benefits. Systemically, NAIs could influence the psychological and physiological health of humans and animals (Iwama, 2004). Among these often-proven benefits, a relaxing effect, a reduction of anxiety and depressive symptoms, associated with a decrease in irritability and blood pressure have been widely demonstrated (Livanova et al., 1999). Used in a context of wellbeing such as in SPAs, this could have a direct and sustainable positive effect. On the contrary, positive air ionization has a negative impact on the mood and learning process (Giannini et al., 1983) because it is associated with a sustainable settlement of fatigue and an increase in systolic blood pressure (Charry and Hawkinshire, 1981). Due to its benefits, the clinical use of NAIs has long been recommended, especially in treatments for burns, asthma and allergic rhinitis (Kellogg, 1984). Practically, treatments using NAIs have been studied in hypertension treatments, fostering healing of known state of stress (Kondrashova et al., 2000). Studies show that short-term exposure to NAIs is a physiotherapeutic method that works with humans (Iwama et al., 2004), including to inhibit certain inflammations or boost the immune system. More recently, it has also been proven that a continuous exposure to NAIs generates antibacterial effects and could stimulate a quick return to homeostasis, which is so important in intense physical activity (Tyagi et al., 2008). However, the short-term efficiency of NAIs in the improvement of sport recovery has not been demonstrated to this day, and even less so combined with far-infrared energy and light-therapy (MLX i³Dome).

In order to analyze the athlete's recovery after exercise-induced muscle damage (EIMD), this study compared two recovery modalities (FIR combined with NAI [MLX i³Dome] and passive recovery) on symptoms of EIMD following a strenuous exercise performed by endurance athletes. We hypothesize that muscle pains, signs of inflammation and muscle performance are less deteriorated when athletes use the MLX i³Dome technology in recovery, within 48h after the intense exercise. This technology must also have a positive influence on athletes' overall wellbeing.

Materials and Methods

Subjects

14 well-trained males participated in this study (Age: 39.4±10.9 yr; Height: 177.4±6.1 cm; Weight: 70.2±8.5 kg; Body Mass Index: 22.3±1.7 kg/m²; Fat mass: 13,5±4,0%).

Experimental design

This study was conducted in order to analyze the effects of MLX i³Dome, compared to a control condition, on measurements of performance and performance-related data after an exercise inducing muscle damage (EIMD).

The EIMD consisted of 2 sets of 14 min separated by a 5 min period of passive recovery (Fig1). Each set was composed of 6 repetitions with 30 sec of supramaximal cycle exercise, 30 sec of passive recovery, 30 sec of repeated countermovement jumps; and repetitions were separated by 60 sec of passive recovery.

All participants tested one of the two recovery conditions during the first week, and the other recovery condition during the second week. The order of the recovery conditions was randomised. The recovery corresponded to a 30 min period of passive recovery, using the MLX i³Dome (Far Infrared Rays therapy [level 10/10], light therapy [green], plasma therapy [ion density: 100% ; ion flow: 50% ; negative ions on the skin: 5 million]) or not (Control). The recovery modality occurred 15 min (Day+0), 24 h (Day+1) and 48 h (Day+2) after the EIMD.

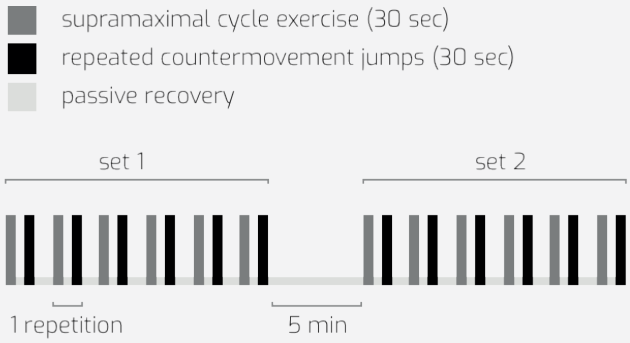


Fig 1. Schematic representation of the exercise inducing muscle damage (EIMD).

For each recovery condition, measurements of performance and performance-related data were conducted just before EIMD (Baseline), between EIMD and recovery, and after recovery during the first day (Day+0 ; Fig 2). Over the next two days, measurements were performed after the recovery (Day+1, Day+2, respectively). Moreover, heart rate variability and muscle soreness were measured 72 h after EIMD (Day+3).

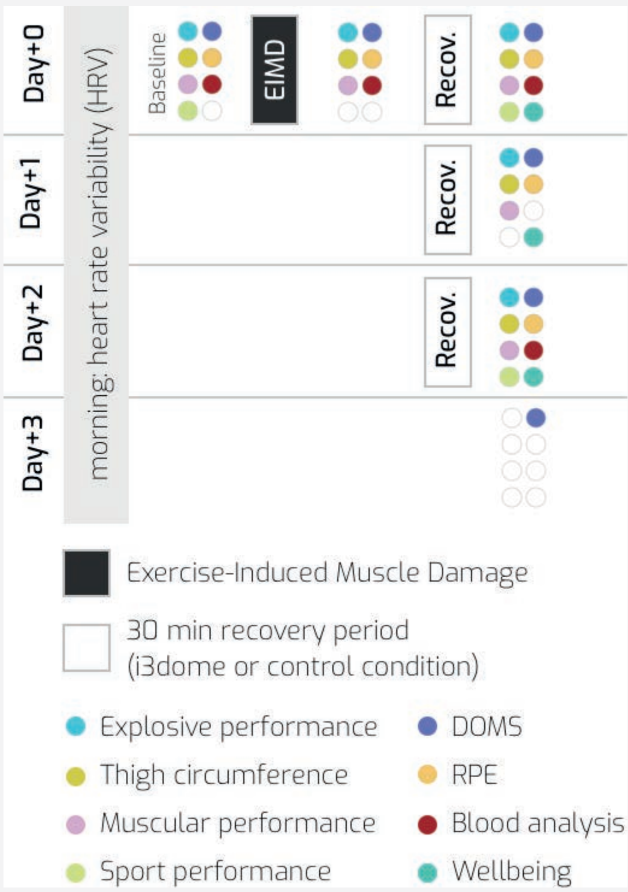


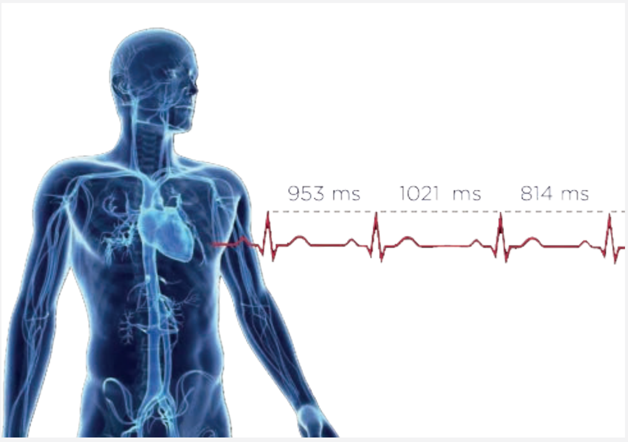
Fig 2. Schematic representation of the experimental design for one of the two recovery conditions.

In order to limit and control the development of additional fatigue, subjects were asked not to train for the two days preceding EIMD, and over the three days of data recording.

Data recording

Heart Rate Variability (HRV)

HRV indexes were evaluated in the morning on waking the day of EIDM (Day+0) and over the following three days (Day+1, Day+2 and Day+3, respectively). RR intervals were collected during using a chest strap heart rate monitor (Polar H9, Kempele, Finland) connected via Bluetooth to a mobile web app (Elite HRV). Subjects were asked to stay lying down and to use earplugs and a night mask for the 4 min of recording of RR intervals. Both breathing rate and depth were left uncontrolled and participants were instructed to relax and breathe at a natural rate. The resting heart rate (HRrest) and HRV indexes (i.e., SDNN and RMSSD) was computed from the collection of RR intervals recording over the last 3 min (i.e., data for the first minute has been dropped).



Picture 1. Illustration of the heart rate variability (HRV).

Thigh circumference

Upon arrival at the laboratory on Day+0, thigh circumference was measured on the right side, 10 cm above the fibula head, by the same experimenter using a non-stretch, flat and flexible measuring tape. This measurement was repeated immediately after EIMD, and after each 30 min recovery period over the 3 days. Circumference measurements were taken as an indicator of acute changes in thigh volume (Brown et al. 1997), likely to occur due to osmotic fluid shifts or inflammation, which has often been associated with muscle-damage and eccentric exercise (Fielding et al. 2000).

Rating Perceived Exertion (RPE)

Before each bout of performance measurement, participants completed a 5 min warm-up at moderate intensity. This intensity was self-selected on the first day of the first week, and kept constant for all warm-ups over the study. At the end of the warm-up and at the end of EIMD, participants evaluated the perceived exertion using the Borg RPE scale going from “extremely light” for level 6 to “extremely hard” for level 20.

Explosive performance (*Squat jump*)

After warm-up, participants performed 3-5 repetitions of squat jumps with a rest interval of 30 seconds between each trail. They started from the upright standing position with their hands on their hips, and they were then instructed to flex their knees and hold a predetermined knee position (~90°) for a count of 3 s. At that point, subjects were instructed to jump as high as possible without performing any countermovement phase. The flight time was measured with Optojump Next bars (Picture 2) connected to a computer, and the Microgate software (Optojump Next Software, version 1.12) allowed jump height calculation, as an index of explosive performance.

Picture 2. Assessment of squat jump height using Optojump Next system.

Delayed Onset Muscle Soreness (DOMS)

Following the squat jump, the level of DOMS was evaluated from a visual analog scale with a sliding mark. The front side of the scale displayed the question “How is your level of muscle soreness at this moment?” and a linear gauge with two items at extremities (bottom: “None” ; top: “Maximal”).

From the bottom, the participants slid the mark along the scale in order to rate their feeling of muscle soreness. On the back side, a numerical scale from 0 (corresponding to the level "None") to 10 ("Maximal") displayed the DOMS value.

Muscular performance (*Voluntary Isometric Contraction*)

Voluntary isometric knee extension force was measured using a leg extension bench instrumented with a steel link chain and a S-force sensor (ME-Meßsysteme GmbH, Germany, Model KD40s, ±5 kN). The length of the link chain was adjusted so that the knee angle was around 100° for each subject. The S-force sensor was connected to a computer using a digital measuring amplifier (GSV-3USB) and the data acquisition software (GSVmulti, version 1.47) for live viewing and recording the measuring data.

For all participants, 2 differents types of tests were performed: firstly, two maximal 3-sec trials, separated by a minimum 1 min rest period, in order to assess maximal muscular performance; secondly, a prolonged duration trial with a maximal implication of 30 sec in order to evaluate average muscular performance.

Picture 3. Assessment of muscular performance using isometric instrumented system.

Sport performance (*Wingate test*)

The Wingate test on a cycle ergometer has been used to assess the anaerobic performance. The test was performed on a Monark Cycle Ergometer LC6 Novo (Monark Exercise AB, Vansbro, Sweden), which was properly adjusted for each subject on the first day (Picture 4). The seat and handlebar settings were recorded to ensure consistency between tests. The Monark Cycle Ergometer was connected to a computer and the Monark Test Software was used to design the Wingate protocol, control the bike and record the data.

Picture 4. Assessment of sport performance using Monark LC6 Novo.

The Wingate anaerobic test started with an initial 30 sec cycling period against a 10N load directly followed by a 30 sec all-out exercise. At the start of this second period, a load defined at 7,5% of the body weight in kg was applied, and the participants were coaxed to pedal as fast as possible, and to maintain pedaling rate as high as possible for 30 sec. At the end of the test, maximal power and average power were calculated from the 1st second of data recording (Fig 3).

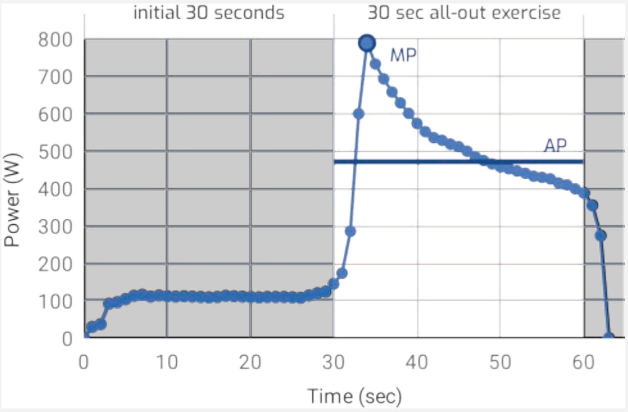


Fig 3. Example of power curve recording at the end of a Wingate anaerobic test. Maximal power (MP) and average Power (AP) corresponding to the highest power value and average power value calculated over the 30 sec all-out exercise.

Blood analysis

Upon arrival at the laboratory on Day+0 (baseline), a micro-capillary blood sample was taken (90 µl) and analysed immediately (EPOC, Epocal Inc., Ottawa, Canada - Picture 5) for glucose, potential hydrogen (pH) and lactate concentration. Blood glucose, pH and lactate concentrations were also measured after EIDM on Day+0, after a Wingate test on Day+0 and Day+2, and after the 30 min recovery period on Day+0 and Day+2 (Fig 2).

Picture 5. Portable blood gas and electrolyte analyser (EPOC).

Rating Wellbeing

After each 30 min recovery period, the level of wellbeing was evaluated from a visual analog scale with a sliding mark. The front side of the scale displayed the question “How are you feeling right now?” and a linear gauge with two items at extremities (bottom: “Neutral” ; top: “Very well”). From bottom, the participant slid the mark along the scale in order to rate their feeling of wellbeing. On the back side, a numerical scale from 0 (corresponding to the level “Neutral”) to 10 (“Very well”) allowed to read the value of wellbeing.

Results

Muscle soreness

Compared from baseline (G-control: 0.8±0.7 ; G-i3dome: 0.8±1.1), DOMS were significantly higher after EIDM for control condition (2.5±2.1 ; P = 0.007) and for i3dome condition (3.0±2.2 ; P = 0.002). Also, DOMS values after EIDM were not different between the 2 groups (P = 0.53).

The level of muscle soreness was high 24 and 48 hours after EIMD, and returned progressively to the baseline value in the control condition. On Day+3, DOMS value was significantly higher compared to baseline (P = 0.03). Using the MLX i3Dome, DOMS values remained at a low level during the 2 days following EIMD and the subjects no longer felt muscle soreness on Day+3 (Fig 4).

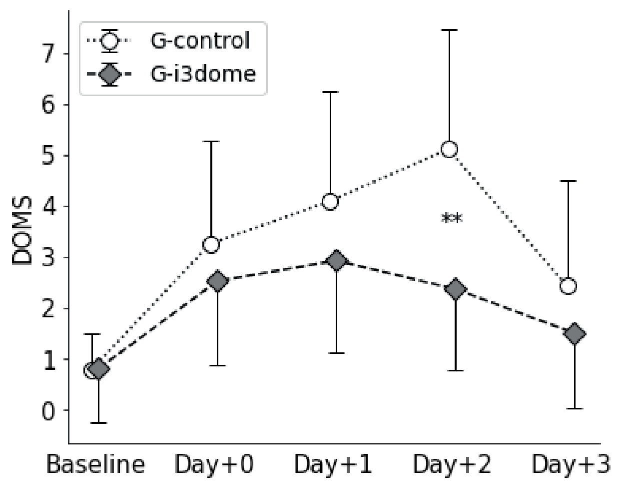


Fig 4. Changes in muscle soresness level over the 4 days with the two differents recovery modalities. **, significant difference between the two conditions (P < 0,01).

Thigh circumference

Immediately after EIMD, thigh circumference increased significantly for the G-control and G-i3dome groups from baseline (1.5±0.8 and 1.8±0.6 cm, respectively), with no difference between the 2 conditions (P = 0.26).

On Day+0, Day+1 and Day+2, changes in thigh circumference compared to baseline were significantly greater in the G-control group compared to G-i3dome group (Fig 5). In the control condition, thigh circumference increased significantly on Day+0 and tended to be higher on Day+1 and Day+2 compared to baseline. In contrast, no significant changes were reported in i3dome condition.

Muscular performance

Maximal muscular force values recorded immediately after EIMD were significantly lower compared to the baseline values, for both the G-control and G-i3dome groups (-15.7% and -12,9% respectively). In addition, muscular performance (both maximal and average force) remained significantly reduced after the first recovery session (Day+0), regardless of the recovery modality (Fig 6). For the G-control group, muscular performance were still decreased over the 2 next days. On the contrary, subjects in the G-i3dome group were able to produce their initial force values at Day+1 and Day+2, suggesting the capacity to maintain their muscular performance on the days following EIMD (Fig 6).

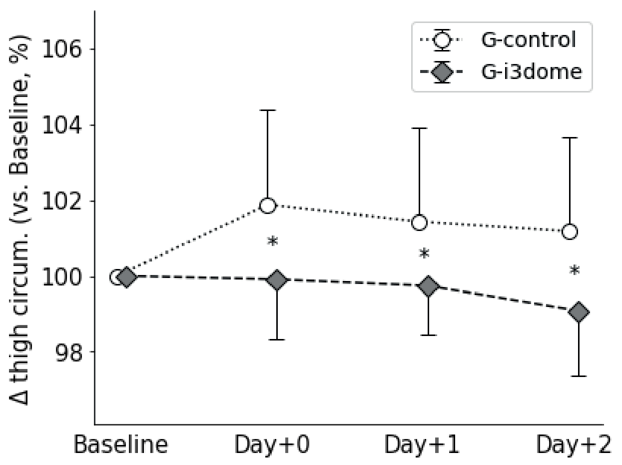


Fig 5. Changes in thigh circumference over the 3 days with the two differents recovery modalities. *, significant difference between the two conditions (P < 0,05).

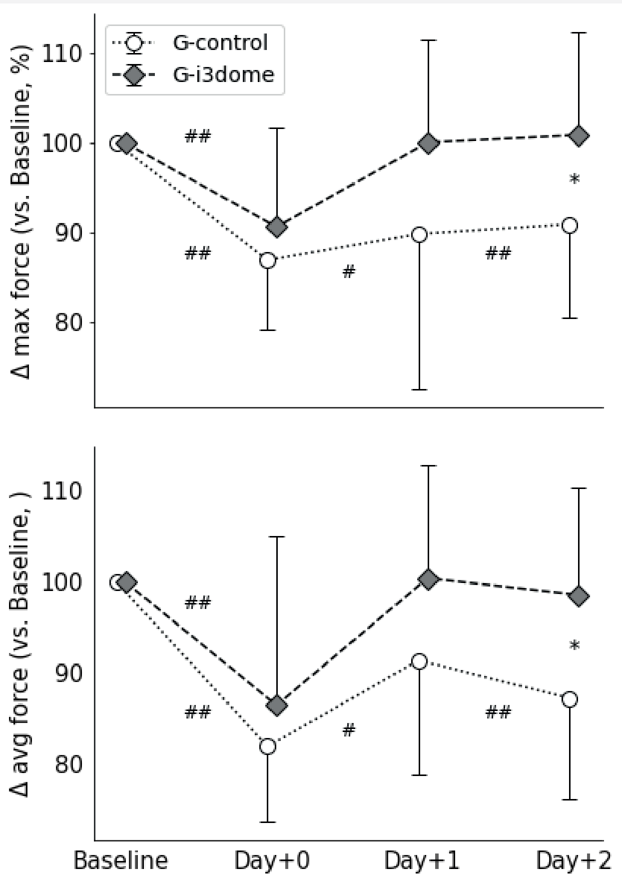


Fig 6. Changes in muscular performance (i.e., maximale and average force) over the 3 days with the two differents recovery modalities. # and ##, significant difference from baseline (P < 0.05 and P < 0.01, respectively). *, significant difference between the two conditions (P < 0,05).

Sport performance

In the control condition, maximal and average power values decreased significantly on Day+0 compared to baseline value. For the G-i3dome group, only the average power was lower on Day+0. The sport performance values returned to baseline values on Day+2 regardless of the recovery modality (Fig 7).

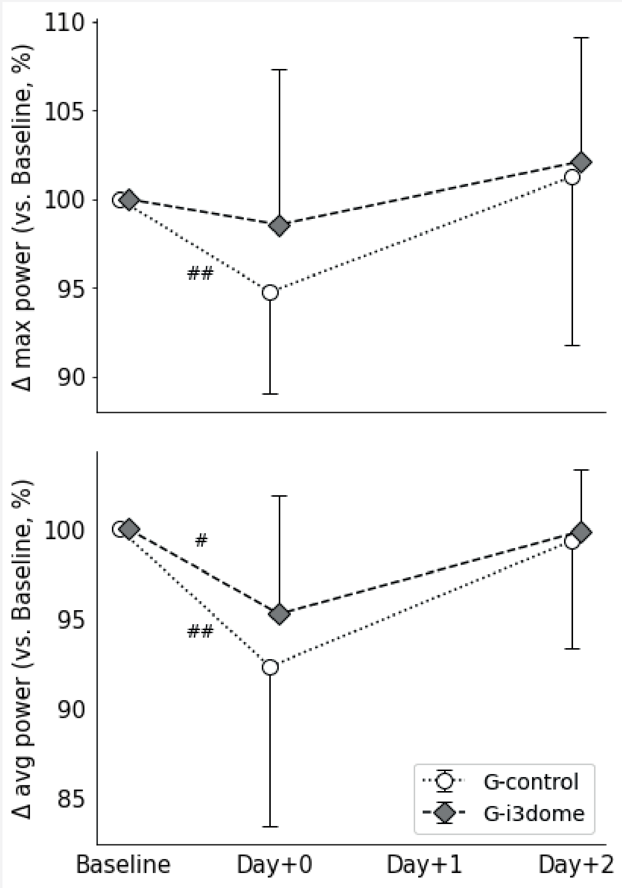


Fig 7. Changes in sport performance (i.e., maximal and average power calculated on the Wingate Anaerobic Test) over the 3 days with the two differents recovery modalities. # and ##, significant difference from baseline (P < 0.05 and P < 0.01, respectively).

Explosive performance

In the two conditions, the height jump decreased significantly after EIDM (G-control: -2.4±3.1 cm ; G-i3dome: -2.9±1.6 cm). However, the initial performance was found since Day+0 after the first recovery session, regardless of the modality. Changes in height jump were not significant over the next 48 hours and not different between the 2 groups (Fig 8).

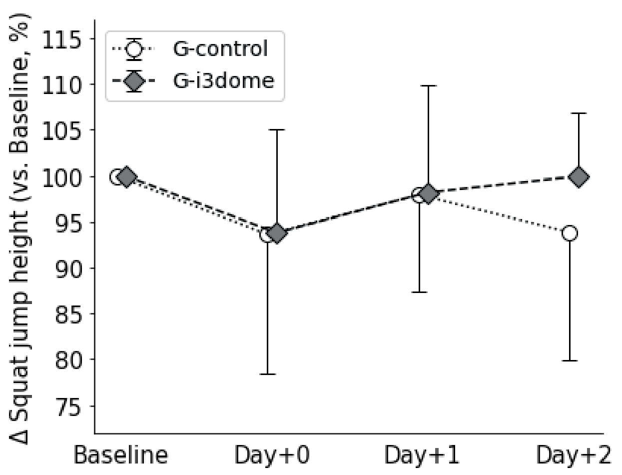


Fig 8. Changes in explosive performance (i.e., jump height) over the 3 days with the two differents recovery modalities.

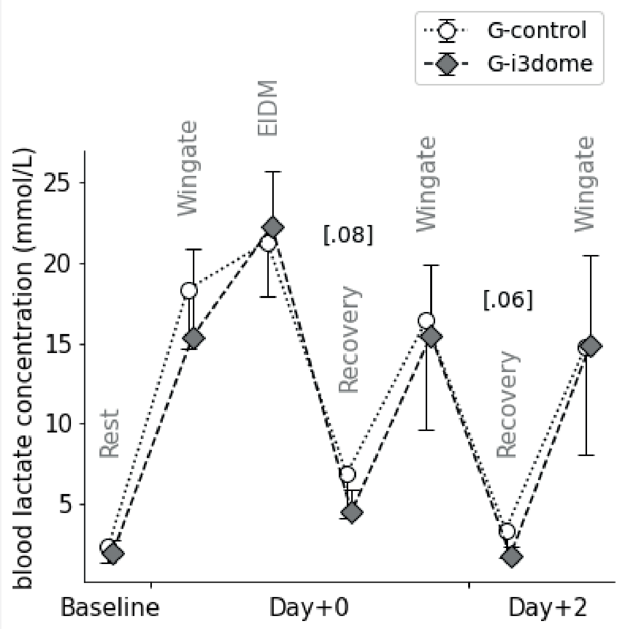


Fig 9. Changes in blood lactate concentration during the different phases of the protocol in the two recovery modalities.

Blood analysis

The blood lactate concentration values measured at rest, after Wingate anaerobic tests, EIDM and 30 min recovery periods (passive or MLX i³Dome) are depicted in Fig 9. No significant difference in blood lactate concentration was reported between the 2 recovery modalities. However, the values obtained after the recovery tends to be lower in the G-i3dome group compared to the G-control group (Day+0: 6.84 ± 2.7 mmol/L vs. 4.48 ± 1.41 mmol/L, P = 0.08; Day+2: 3.36 ± 1.73 mmol/L vs 1.77 ± 0.54 mmol/L, P = 0.06).

Baseline and maximal values of blood glucose and pH concentrations obtained for the G-i3dome group were not significantly different compared to the G-control group. However, pH measured directly after the 30 min recovery period at Day+0 was significantly lower in G-control (Table 1).

Perceived exertion

Values of perceived exertion (RPE) evaluated at the end of EIDM were close between the 2 conditions: 17.4±1.3 and 17.5±1.3 for the G-control and G-i3dome groups, respectively. These values suggested that intensity and physical implication during EIMD were similar during the first and second week.

RPE values evaluated during warm-up significantly increased after EIMD and over the next days for the G-control and the G-i3dome groups. Moreover, no significant difference was reported between the 2 conditions in RPE values during warm-up at baseline, Day+0 and Day+2 (Fig 10).

Table 1. Rest blood pH and glucose concentrations measured after the 30 min recovery period in the two differents recovery modalities.

Parameters		G-control	G-i3dome	Probability	Cohen's d
pH	Day+0	7.384 ± 0.034	7.462 ± 0.071	0.005**	1.41
	Day+2	7.410 ± 0.037	7.424 ± 0.032	0.387	0.39
Glucose	Day+0	0.966 ± 0.152	0.94 ± 0.077	0.635	0.21
	Day+2	1.018 ± 0.152	0.982 ± 0.096	0.534	0.28

**, significantly different between G-control and G-i3dome (P < 0.01). The criteria to interpret the magnitude of the effect size were as follows: >0.2 small, >0.5 moderate, >0.8 large, and >1.3 very large).

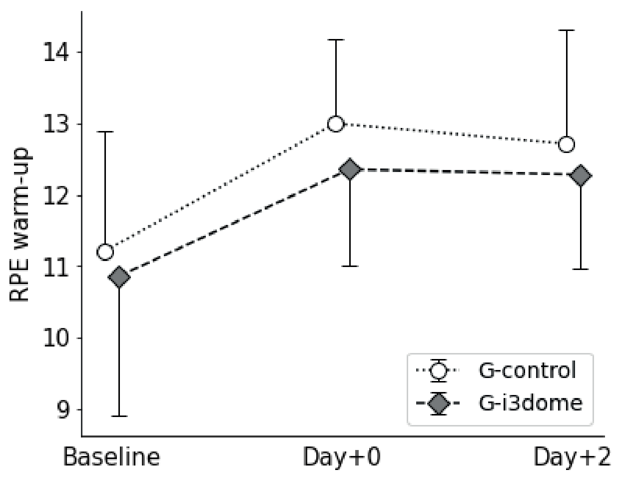


Fig 10. Changes in perceived exertion level during warm-up over the 3 days with the two differents recovery modalities.

Wellbeing

The wellbeing levels assessed over three days, immediately after the 30 min recovery period, showed no change in the G-control condition. However, the wellbeing tended to increase day by day in the G-i3dome group (Fig 11). Moreover, wellbeing evaluated on Day+1 and Day+2 was significantly higher in the G-i3dome group compared to the G-control group.

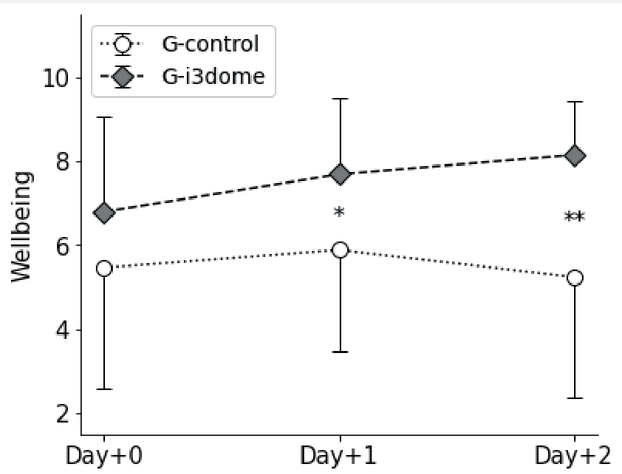


Fig 11. Changes in wellbeing level over the 3 days with the two differents recovery modalities.* and **, significant difference between the two conditions (P < 0,05 and P < 0.01, respectively).

Heart rate variability

Changes in HRV indices are depicted in Fig 12. No significant interaction between the days and the conditions was reported on SDNN or RMSSD. However, RMSSD which reflects parasympathetic activity, trended to be higher in Day+3 compared to baseline in G-i3dome (P = 0.09).

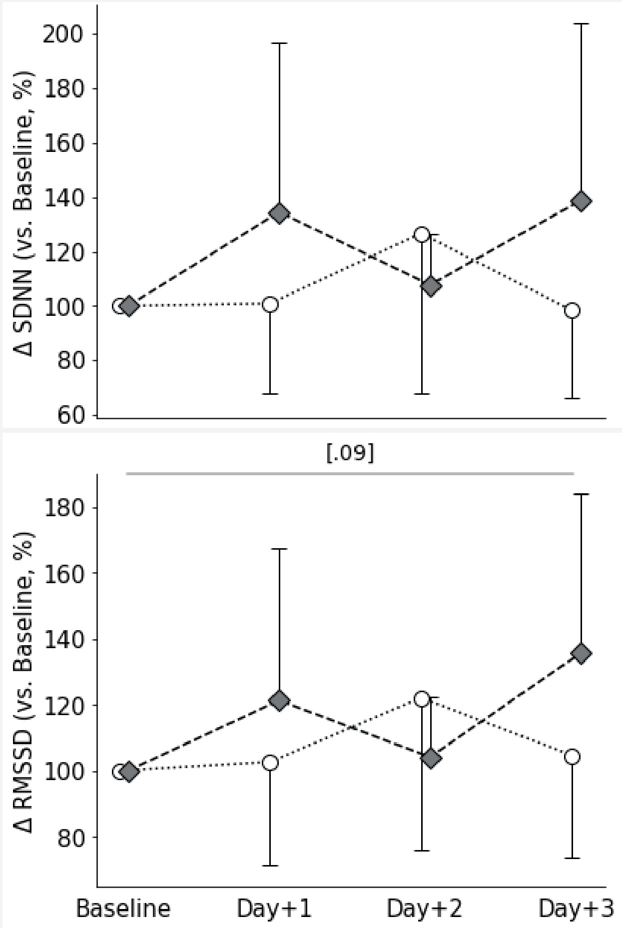


Fig 12. Changes in the heart rate variability indexes (SDNN and RMSSD) over the 4 days with the two differents recovery modalities.

Take-home messages

This study aims to evaluate the effects of 3-session of MLX i³Dome as a sport recovery method on performance-related data compared to a control group. The main results to remember from the present study are:

MUSCLE DAMAGE is lower when MLX i³Dome is used as recovery from strenuous exercise:

- Muscle soreness remained at low level the 2 days following the exercise and participants no longer felt muscle soreness on Day3.
- Muscle inflammation, as represented by thigh circumference, increased by 1.9% over the 3 days of recovery in control condition but no changes were reported in MLX i³Dome condition, meaning that far-infrared is completely efficient to prevent the muscle from inflammation.

SPORTS and MUSCULAR PERFORMANCES are maintained when MLX i³Dome is used as recovery from a very demanding exercise:

- Muscular fatigue was higher for the control group by almost 12.9%; however, participants were able to reproduce both their initial and mean forces on Day1 and Day2 after exposure to far-infrared, then decreasing to a large extend the level of muscular fatigue,

- Sports performance - as represented by maximal power in cycling - is maintained after recovery with far-infrared, unlike the control group which decreased its performance by -5.2% on Day0.

GLOBAL WELLBEING is improved on the 2 days of MLX i³Dome recovery from a high challenging exercise:

- Wellbeing ratings were highly elevated (Day1: +7.9% and Day2: +30.1%) compared to the control group, meaning that MLX i³Dome provides essential and relevant wellbeing for all subjects.
- Vitality index – represented by Heart Rate Variability (HRV) – is increased by 36% on Day3 after the 3-session of MLX i³Dome.

BLOOD ACIDOSIS is improved immediately after the first session of MLX i³Dome and 2 days after from a very intensive exercise:

- Blood pH was more elevated on Day0 than the control group, meaning that a single session of MLX i³Dome induced a high alkalosis (54.7%): this is relevant to prevent decrease in blood acidosis due to intense exercise.
- Blood waste – often associated with high lactate production and perceptual discomfort – were lower by -34,5% on Day0 and by -47,3% on Day2, in comparison with the control group.

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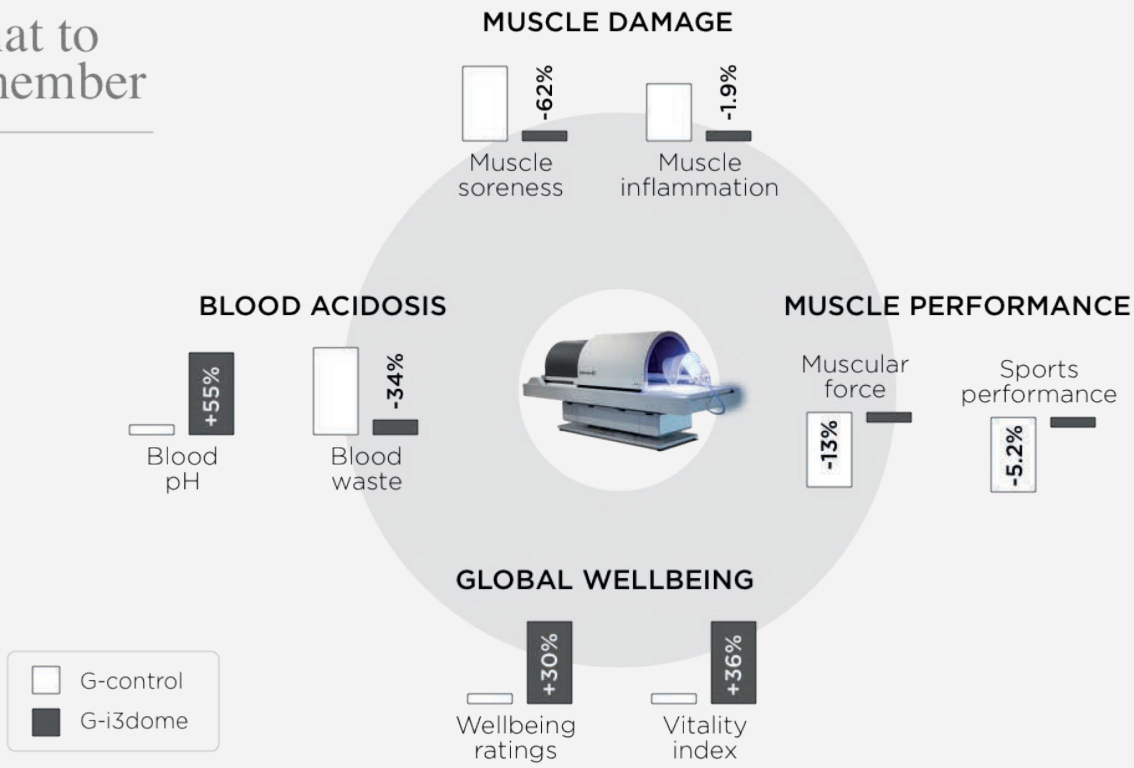
What to remember



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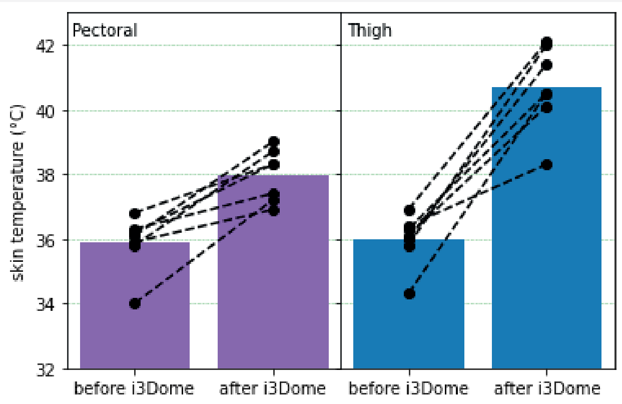
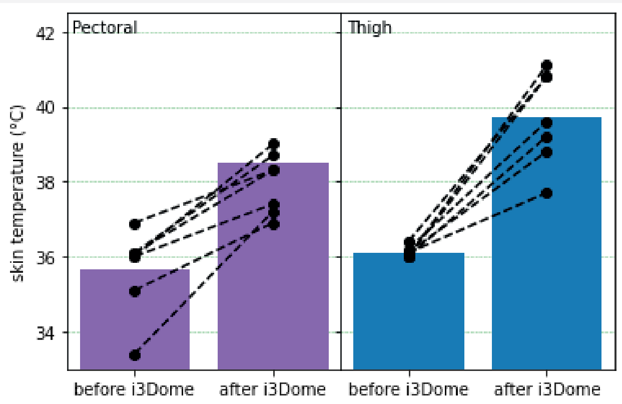
Annexe

Changes in skin temperature

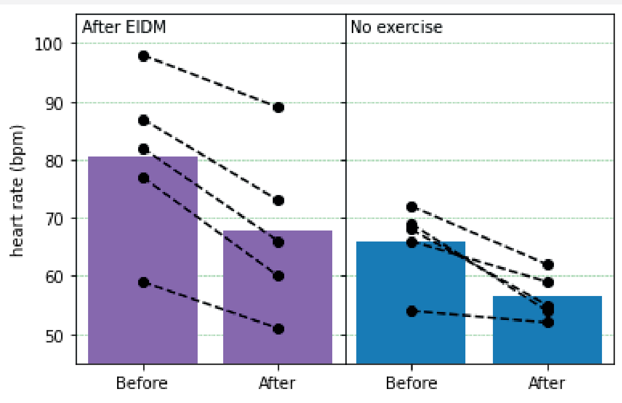
After a 30 min period in the MLX i³dome, changes in skin temperature measured on the pectoral area and on the thigh area are depicted in the figures below. In the first chart, subjects had performed EIDM before MLX i³dome. In the second chart, none exercice was completed.





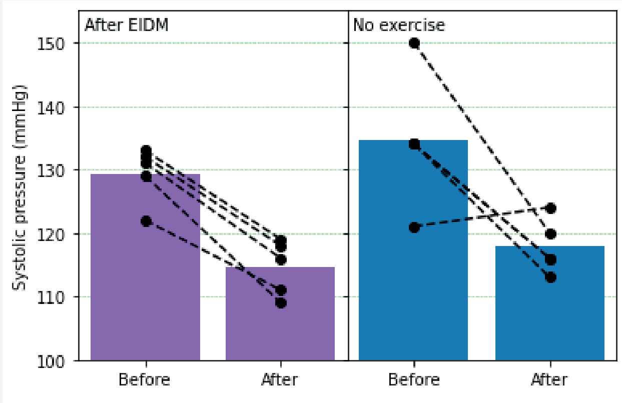
Changes in heart rate

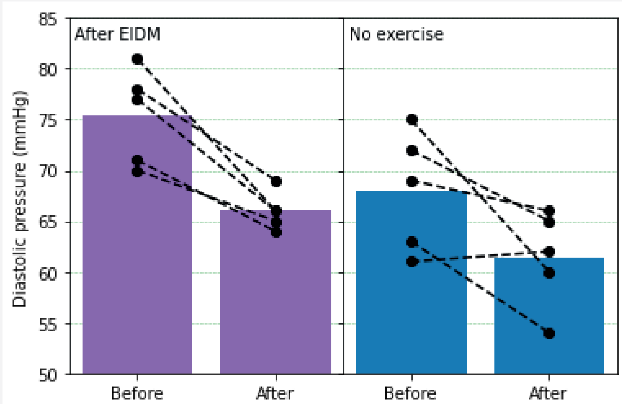
After a 30 min period in the MLX i³dome, changes in heart rate is depicted in the figure below.



Changes in blood pressure

After a 30 min period in the MLX i³dome, changes in blood pressure measured are depicted in the figures below. The first chart displays the changes in the systolic blood pressure. The second chart displays the changes in the diastolic blood pressure.





beScored Institute

Christophe **HAUSSWIRTH**

Founder beScored Institute

christophe@bescored.institute

+33.6.86.58.46.93